PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G02F 1/11

A1

(11) International Publication Number: WO 99/03016

(43) International Publication Date: 21 January 1999 (21.01.99)

(21) International Application Number: PCT/US98/12463

(22) International Filing Date: 19 June 1998 (19.06.98)

(30) Priority Data:

60/051,973	8 July 1997 (08.07.97)	US
09/092,321	5 June 1998 (05.06.98)	US

(71) Applicant: ETEC SYSTEMS, INC. [US/US]; 26460 Corporate Avenue, Hayward, CA 94545 (US).

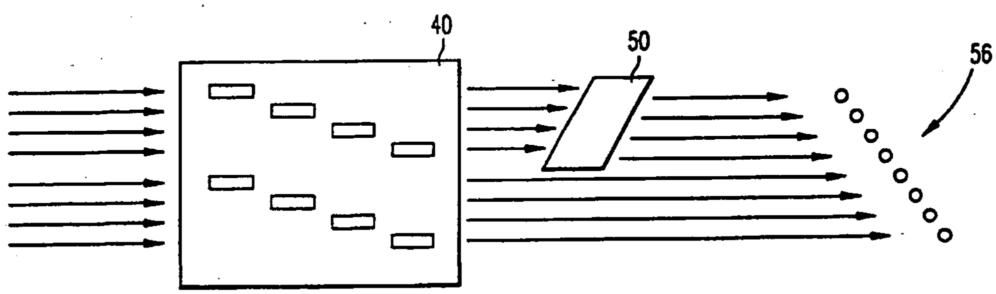
(72) Inventors: YAO, Shi-Kay; 9060 Telstar Avenue #225, El Monte, CA 91731 (US). TAMKIN, John, M.; 11306 N. Copper Springs Trail, Oro Valley, AZ 85737 (US).

(74) Agents: MILLERS, David, T. et al.; Skjerven, Morrill, MacPherson, Franklin & Friel LLP, Suite 700, 25 Metro Drive, San Jose, CA 95110 (US).

(81) Designated States: CA, CN, IL, JP, KR, MX, RU, SG, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: ACOUSTO-OPTIC MODULATOR ARRAY WITH REDUCED RF CROSSTALK



(57) Abstract

The electrical (RF) crosstalk in multi-channel laser beam systems using an acousticoptic modulator is minimized. This is done without reducing packing density by arranging the modulator electrodes (44a, .., 44h) in a two dimensional array. The electrodes in each column are staggered relative to the electrodes in adjacent columns. While this introduces a problem of potential gaps between the resulting laser beam spots, this gap is corrected by a beam translation device (50) located in the optical path of certain of the laser beams.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

ACOUSTO-OPTIC MODULATOR ARRAY WITH REDUCED RF CROSSTALK

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of the filing date of U.S. provisional application Ser. No. 60/051,973 filed July 8, 1997.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to modulation of light beams and more specifically to an improved acousto-optic modulator with higher packing density of the modulated laser beams.

Description of the Prior Art

Multi-channel laser beam systems used for instance in laser writing applications, such as imaging patterns onto photo-resist using multiple laser beams for purposes of creating electronic circuit substrates, use the well known acousto-optic modulator array. In such a modulator, electrical energy is converted to acoustic waves by a piezoelectric transducer, and the acoustic waves modulate the incident laser (light) beams. The acoustic waves distort the optical index of refraction of the modulator body, typically made of crystalline material or glass, through which the laser beams pass. This distortion is periodic in space and time and thus provides a three dimensional dynamic diffraction grating that deflects or modulates the laser beams. Such acousto-optic devices are well known in broadband signal processing.

An example of such modulator 10 is shown in Fig. 1A illustrating the exterior of the modulator body 14. The light beam 16 enters from the left surface of the body 14 and passes through the body 14. The horizontal lines are intended to suggest diffraction grating properties; it is to be understood that the molecules in the modulator body, compressed or stretched by the presence of acoustic waves, provide the effect of a three dimensional dynamic phase grating and it is not a conventional diffraction grating. The electrical input signal ("input") is applied to the surface electrode 20 of the transducer body 21 which is made

of a thin platelet of piezoelectric material bonded to the surface of the modulator body 14. Transducer body 21 is located under electrode 20. Light beam 16 enters the body 14 through the surfaces orthogonal to the surface to which the piezoelectric transducers 21 are bonded. The frequency and power of this electrical input signal determines to what extent the light beam 16 is deflected by passing through the modulator body 14 due to the presence of the resulting acoustic wave. Conventionally an acoustic termination such as an acoustic absorber 22 is provided on the surface of the modulator body 14 opposite to the surface on which the transducer body 21 is bonded and the electrical signal is applied. Alternatively, the surface of the modulator body opposite to the surface on which transducer 21 is bonded may be cut at an angle causing incident acoustic waves to reflect off-axis and eventually be absorbed by the modulator body.

Thus the electrical connection with electrode 20 and (ground) electrode 24 provides an electrical input port and the voltage (signal) applied thereto creates a spatially uniform electric field in the piezoelectric active regions of transducer body 21 to cause the generation of a uniform acoustic wave traveling down the modulator body 14, which in turn, causes the intended deflection of the light beam 16. Due to photo-elastic coefficients of the modulator material 14, the actual effect is caused by appreciable variations in the refractive index of the modulator body 14 which in effect creates a moving (dynamic) diffraction grating traveling at the speed of sound with a grating strength determined by the input electrical power. The angle of deflection of the output light beam and its magnitude as produced by the moving diffraction grating depends on the frequency and the amplitude of the acoustic wave.

Fig. 1A shows only a single transducer 21 with input electrode 20 for modulating a single incident light beam 16. "Light beam" in this context refers to any electro-magnetic radiation which may be so modulated, including not only visible light but also ultraviolet light and other frequencies including infra-red, etc., from a laser or other source.

In multi-channel laser beam systems as shown in Fig. 1B which is the top view of a multi-channel modulator, from the electrode side, a plurality of incident laser (light) beams 16a, 16b, 16c, 16d are applied to a single modulator body. The modulator body has formed on its surface a corresponding number of transducer electrodes 20a, 20b, 20c, 20d, one transducer electrode for each beam to be modulated. Such a device as illustrated in top view in Fig. 1B has the plurality of electrodes 20a, 20b, 20c, 20d on the surface of transducer body

21 which is on the modulator body 14. Typically there are 4 or 8 or more such electrodes, each deflecting a corresponding incident beam. The physical size of each electrode is inversely proportional to the square of modulator bandwidth (speed) and can be very small for the case of a high speed modulator array, on the order of a few hundred micrometers by a few millimeters each for modulator bandwidth on the order of tens of megahertz. It is a common practice to form such modulator transducer arrays using conventional photo-lithographic means to define the small electrodes. However, to prevent a short circuit, the electrodes are made with a finite gap in between.

In typical laser imaging systems the intended application is to form an array of tiny laser beam dots, modulated in time, on the imaging medium, the dots having a typical packing density of 300 to 10,000 or more dots per inch. Moving the modulated optical dot array in a direction nominally orthogonal to the dot array orientation, i.e. raster scanning, on optically sensitive medium will produce a recorded image of the modulating signal. Obviously, in order to print a continuous quality pattern, there shall be no noticeable gap between adjacent laser beam dots on the optically sensitive medium.

Since the desired laser beam dots tends to be substantially smaller than the laser beams in the modulator array, optical imaging techniques are employed to reduce the laser beam diameters and to eliminate the gaps between adjacent modulated laser beams from a modulator array.

Fig. 2A (left side) illustrates the optical output beams from a four channel linear modulator array in the prior art having finite gaps between adjacent laser beam dots, and the associated laser beam intensity (right side). These gaps can be reduced or even eliminated when the scanning direction is rotated relative to the orientation of the laser beam array as further illustrated by Fig. 2B. For the case of a one dimensional array of Fig. 2A, each gap between adjacent channels has the same vector quantity **d**. Rotation of the line image by an angle α in Fig. 2B causes each and every gap between dots to be reduced to a distance of $d(\cos \alpha)$. The gap is effectively eliminated in the scanned pattern (see right side of Fig. 2B) when $d(\cos \alpha)$ is made approximately equal to the laser beam diameter. When $d(\cos \alpha)$ is smaller than the laser beam diameter, the resultant optical intensity distribution can be very smooth.

However, after rotation of the scan direction, the writing beams will be separated along the direction of scan, see Fig. 2B. The first line of the raster pattern will be printed ahead of the subsequent lines. The staggered scan lines can be compensated by delaying the RF input signal to each of the channels an amount equal to its time lead relative to the adjacent beam. With proper delays in the beams the spread modulated beam dots can be effectively brought into "line". See e.g. U.S. Patents 4,796,038 and 4,806,921.

In Fig. 1C, the acoustic wave must travel a certain distance to engage the incident laser beam, resulting in an acoustic delay of the signal. In practice, there may be small but finite variation in this distance, and thus variation in signal delay among the modulated laser beams. This variation is eliminated by subtracting it from the electrical delays to bring the modulated beam dots into "line".

However the problem exists of excessive channel-to-channel cross-talk in a densely packed modulator array due to both acoustic proximity and electrical proximity. Acoustic cross-talk between the traveling acoustic waves generated by each electrode 20a, ..., 20d is usually well behaved according to wave diffraction theory and can be minimized by geometric considerations of the transducer electrodes and the modulator body. However the electrical RF (high frequency) cross-talk in the incoming signals applied to the transducer array is more difficult to eliminate and is usually the dominating source of cross-talk. This problem is particularly difficult since inductive RF coils are needed for impedance matching of the transducer electrodes 20a, ..., 20d in addition to the close proximity of the feed conductors and the bonding wires (not shown) connecting to each transducer electrode 20a, ..., 20d.

In order not to obstruct the incident laser beams, the electrical feeds for the transducer electrodes have to come in from the two sides of the modulator transducer array. A large number of feed conductors must be squeezed to an area of only a few millimeters, the length of a transducer electrode. If the transducer elements can be spread in the direction parallel to the incident light beams, the tight packing density can be eased resulting in a two dimensional array of modulators.

Another important property of the acousto-optic modulator array is the bending of the optical axis in the middle of the modulator body. Fig. 1C is a side view of the structure of Fig. 1B showing only the first electrode 20a with its connecting wire 26. (The other

electrodes are exactly in line with electrode 20a and hence not visible.) The group of parallel horizontal lines suggest a diffraction grating which of course is not visible in fact. The incidence angle (measured in the air, external to the modulator body 14) of the laser beams 16a is the well known Bragg angle, θ_B, which is given by $\theta_B = \sin^{-1}\frac{\lambda}{2\Lambda}$ where λ is the wavelength of the incident laser beam 16a in air and Λ is the acoustic wavelength. The output laser beams are symmetrical to the acousto-optic diffraction grating, and have an exit angle of also θ_B. Thus, as shown, the incident laser beam 16a undergoes a bend in propagation direction in the middle of the acousto-optic modulator by the total deflection angle, $2\theta_B$.

SUMMARY

In accordance with this invention, instead of a single one-dimensional column of electrodes, the transducer electrodes are spread in the direction of laser beam propagation, allowing more spacing for the RF feed circuit.

For a modulator array with a large number of channels, the transducer electrodes can be arranged two dimensionally in a plurality (at least two) of columns, each column including at least one electrode. This two dimensional acousto-optic modulator array allows substantial increased physical separation in both dimensions between adjacent modulator elements (electrodes). The greater physical separation makes it easier for improved electrical isolation among the feed conductors to the modulator array and allows closer effective channel to channel separation.

However it has been found by the present inventors that a two dimensional modulator array may introduce undesirable image artifacts, due to a problem related to the bending of the optical axis in the middle of an acousto-optic modulator. Hence additional care must be given in order to eliminate print gaps between adjacent scan lines.

For a two dimensional array, there are rows of modulators due to the parallel columns. Bending of the optical axis in the middle of each modulator causes output beams from modulators in a row to exhibit lateral off-set of ($2D \sin\theta_B$) where D is the element-to-element separation in the row of modulators. Thus, the output beams of each entire column exhibit a common lateral off-set related to their order in the row. As a result, the output beams from a

two dimensional modulator array exhibit a two dimensional distribution instead of a linear distribution.

In general, when the two dimensional output laser beam array is rotated relative to the scan direction by an amount to close the vertical separation between adjacent elements in a row, a row-to-row gap G may result in the effective writing beam array.

A correction in accordance with this invention brings the resulting beams into a distribution having uniform pitch (spacing) between all adjacent beams.

In one embodiment, the row-to-row gap in the image is removed by providing a beam translation device such as a tilted parallel plate in the optical path of certain elements of the beams after the modulator array. This has been found to bring the beams from all channels into a single straight line of uniform pitch.

Alternatively, the incident laser beams are prearranged at their source, e.g. by a tilted parallel plate, so that they form a straight line (or have uniform pitch) upon emerging from the modulator body.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A, 1B, and 1C show prior art acousto-optic modulator arrays.

Figs. 2A and 2B show a prior art one dimensional electrode array and resulting scan pattern.

Fig. 3 shows an example of a two dimensional electrode array for a modulator array in accordance with this invention.

Fig. 4 illustrates how a row of modulators in accordance with this invention deflects aligned incident beams to exhibit lateral displacements.

Figs. 5A, 5B, 5C, and 5D show in accordance with this invention a two dimensional electrode array and resulting scan pattern.

Fig. 6 shows use of a tilted parallel plate for gap compensation in accordance with this invention.

Fig. 7 shows an alternate location for a tilted parallel plate.

DETAILED DESCRIPTION

Fig. 3 shows a transducer electrode array on a surface of an acousto-optic modulator body 40 in accordance with this invention. Shown in this example are eight electrodes arranged in columns. Other features such as the wires connecting to the electrodes and the acoustic absorber are not shown since they are conventional as described above; only the arrangement of the electrodes is different. In this case there are four columns; the first column includes electrodes 44a, 44e, and the columns as shown are staggered. The separation between columns is limited by the optical depth of focus, because all acousto-optic modulators must be placed within the focus of the incident laser beams to achieve peak modulation speed and diffraction efficiency. For a typical laser beam diameter of several hundred microns, the depth of focus can be many centimeters, allowing a long row of modulators or a row of parallel columns.

While Fig. 3 shows two electrodes per columns, in other embodiments there is only one electrode per column, or more than two per column.

Thus advantageously the physical separation between adjacent modulator elements (electrodes) is increased significantly, thereby making RF signal isolation easier.

However, there is a unique property with this electrode array, relating to the bending of the optical axes in the middle of the acousto-optic modulator of Fig. 3, as shown in the side view of the same structure, Fig. 4. The lateral displacement of adjacent beams in a row of modulators is shown in Fig. 4 as being equal to ($2D \sin \theta_B$), where D is the pitch between adjacent electrode columns and θ_B is the Bragg incidence angle.

When the number of channels is small, it is possible to arrange all elements of the modulator array in one slanted row, elements 44a, 44b, 44c, and 44d only of Fig 3. The resultant beam spots will remain in a straight line although at a slanted angle, at the electrode separation in the column direction and at the compressed electrode separation ($2D \sin \theta_B$) in the row direction.

For the output of a two dimensional acoustic-optic modulator array of Fig. 3, the laser beam spots form a two dimensional distribution of laser beams shown by Fig. 5B instead of the desired simpler linear distribution as provided by the prior art of Fig. 1A.

Figs. 5A, 5B, 5C, 5D illustrate the two dimensional modulated beam array with an eight channel modulator array as in Fig. 3 having eight electrodes arranged in four columns of

electrodes, where the pitch between electrodes is D. The optical output (beam spots) of this array as shown in Fig. 5B has two lines each of four dots with the spacing ($2D \sin\theta_B$) along the x (horizontal) direction and d along the y (vertical) direction. After rotating the beam array relative to the scan direction to eliminate the gap between adjacent scan lines, the scan line arrangements will be as shown in Fig. 5C and the laser intensity profile along the y-direction is shown by Fig. 5D which is two groups of continuous scan-lines separated by a gap G. In general, this gap is not desirable. In Fig. 5C, $d' = d\frac{\sin(\beta - \phi)}{\sin\beta}$ where $\beta = \tan^{-1}\left(\frac{d}{2D\sin\theta_B}\right)$ where ϕ is the rotation angle.

Approaches to solve this problem are as follows.

One method is to provide a beam translation device as shown in Fig. 6. This device is for instance a tilted "parallel plate" 50 which is a tilted (relative to the beam axis) plate of optically flat glass which laterally translates (displaces) some of the beams (channels) indicated by the horizontal lines in Fig. 6. The tilt angle of this plate 50 is a function of the amount of beam displacement needed to overcome the above-described gap. Hence as shown in Fig. 6 a single tilted parallel plate 50 is introduced into the common optical path for channels 1 through 4 (the top portion) of an eight channel modulator array 40, thereby putting all eight beams into a single straight line of uniform pitch as shown in the resulting written pattern 56.

This parallel plate 50 alternatively is located "upstream" of the transducer (modulator 40), as shown in Fig. 7 to achieve a "pre-tilt". Alternatively, multiple tilted parallel plates could be provided, depending on the modulator array arrangement. For instance additional channels may require additional parallel plate(s).

The arrangement of Fig. 7 has been found advantageous because prior to entering into the modulator, the beam spots are of larger diameter and therefore the spacing between channels greater, so the criticality of the tilt angle of tilt plate 50 is less. In addition, it may be easily accomplished as part of the beam splitter array that sets up the multiple laser beams for the modulator array.

The particular shape of the electrodes has been found not to be critical for use of the present two dimensional electrode array invention. A typical application uses relatively long

and narrow electrodes having an aspect ratio of e.g. 10 or more, although this is not limiting. The electrodes may be e.g. rectangular, diamond, or other shapes. A typical shape and size of an electrode is an elongated rectangle of dimensions 300 μm by 6 millimeters (6000 μm), providing a 20 to 1 aspect ratio. A typical corresponding beam spot diameter beam is 100 to 200 microns at the center of the modulator body.

This description is illustrative and not limiting; further modifications will be apparent to one skilled in the art in the light of this disclosure and are intended to fall within the scope of the appended claims.

CLAIMS:

1. An acousto-optic modulator comprising:

a transducer body suitable for passage therethrough of a plurality of incident beams of radiation; and

a plurality of electrodes on a surface of the transducer body, one of the electrodes being associated with each of the beams of radiation, wherein the electrodes are arranged in an array having a plurality of rows and columns relative to an axis defined by the incident beams of radiation.

2. The modulator of Claim 1, wherein the array includes at least one electrode in each column.

3. The modulator of Claim 2, wherein the electrodes in a first column are staggered relative to the electrodes in a second adjacent column.

4. The modulator of Claim 1, wherein an aspect ratio of each electrode is at least ten to one.

5. The modulator of Claim 1, further comprising a beam translator arranged to translate those of the beams incident thereon.

6. The modulator of Claim 5, wherein the beam translator is located between the transducer body and a source of the beams.

7. The modulator of Claim 5, wherein the beam translator is located between the transducer body and a destination of the beams.

8. The modulator of Claim 5, wherein the beam translator is a transparent plate tilted at an angle to an axis of the beams incident thereon.

9. The modulator of Claim 5, wherein the electrodes are arranged in two groups, and only the beams incident on one of the electrode groups are also incident on the beam translator.

10. The modulator of Claim 1, further comprising means for arranging the beams collectively to define a uniform pitch after passing through the transducer body.

11. A method of modulating a plurality of incident beams of radiation, comprising the steps of:

providing the plurality of incident beams arranged one along side another; and

acoustically deflecting the beams two dimensionally relative to an axis defined by the incident beams, thereby modulating the beams.

12. The method of Claim 11, further comprising the step of translating a portion of the beams, whereby the beams after being translated and deflected are arranged at a uniform pitch one-to-another.

13. The method of Claim 12, wherein the step of translating occurs after the step of deflecting.

14. The method of 12, wherein the step of translating occurs before the step of deflecting.

15. The method of Claim 11, further comprising the step of arranging the incident beams before they are acoustically deflected such that after being acoustically deflected, the beams collectively define a uniform pitch one-to-another when incident on a target.

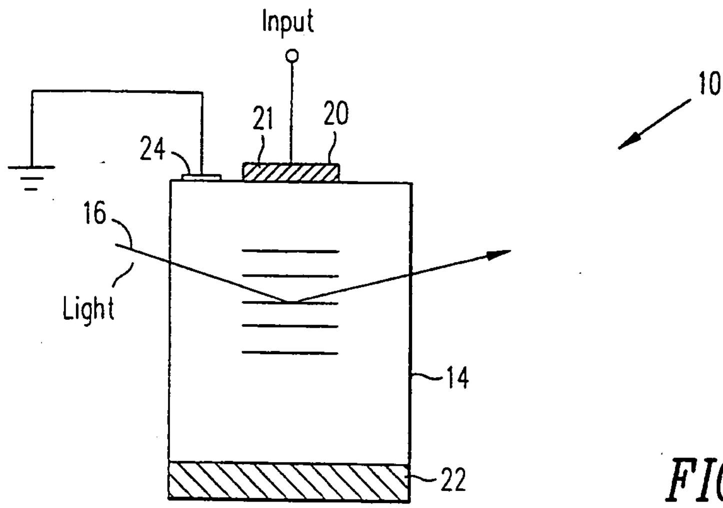


FIG. 1A
(Prior Art)

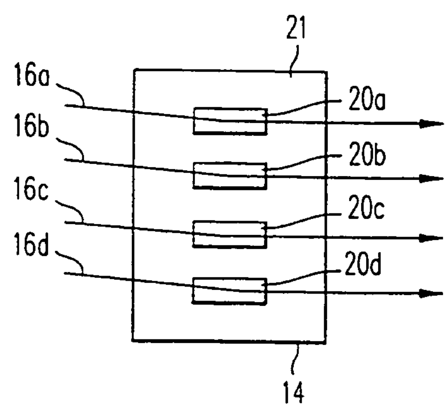


FIG. 1B
(Prior Art)

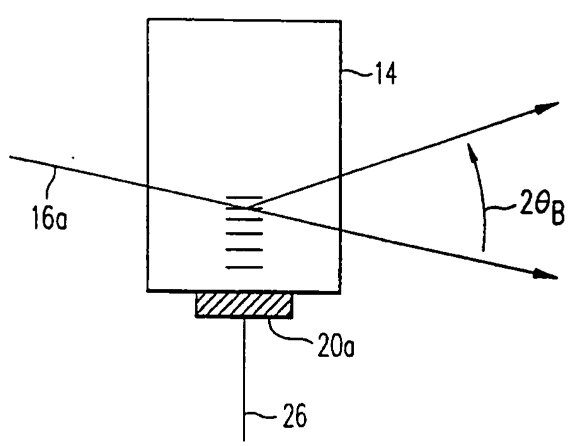


FIG. 1C
(Prior Art)

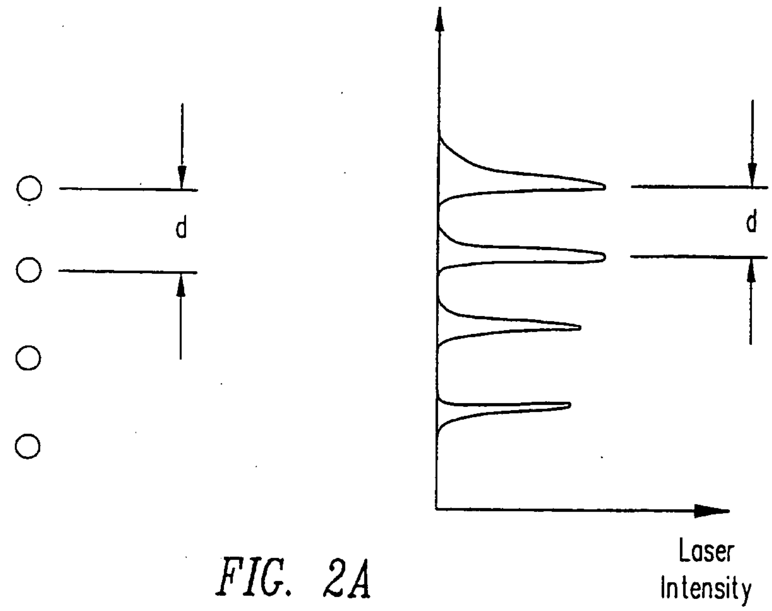


FIG. 2A

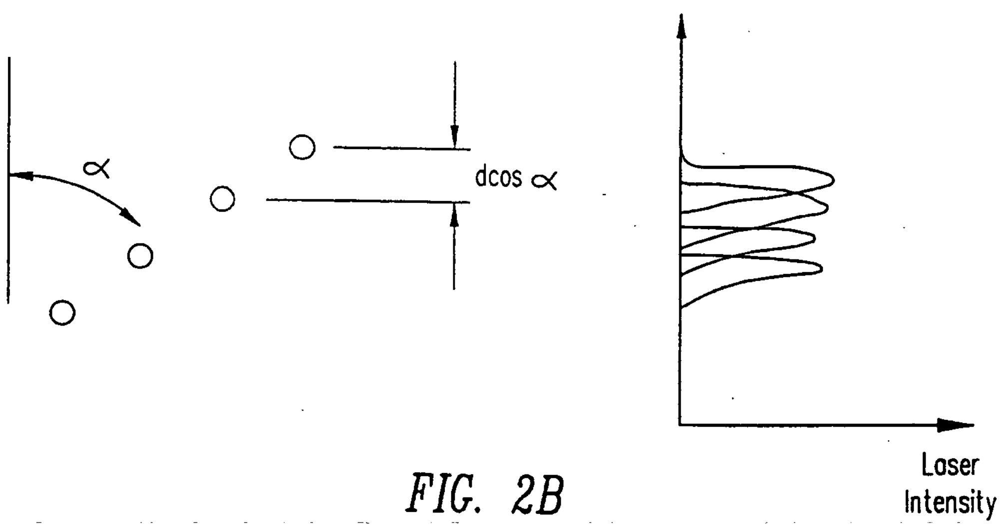


FIG. 2B

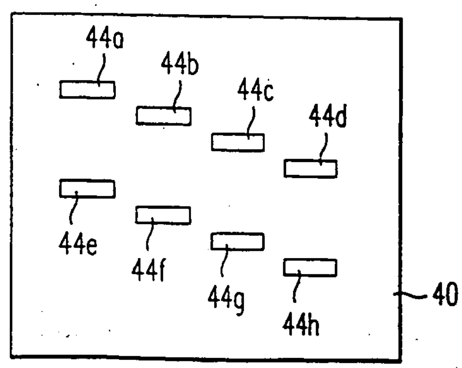


FIG. 3

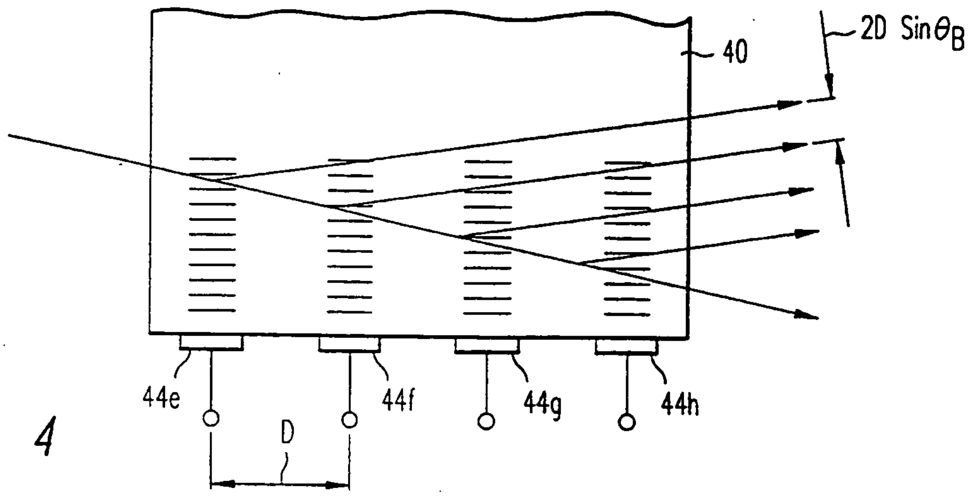
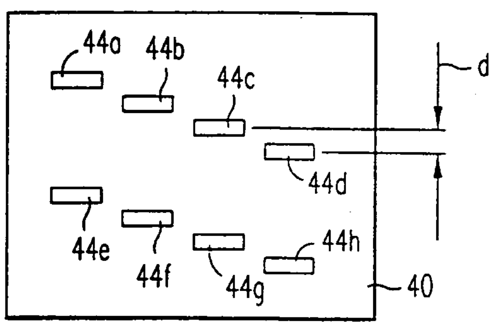
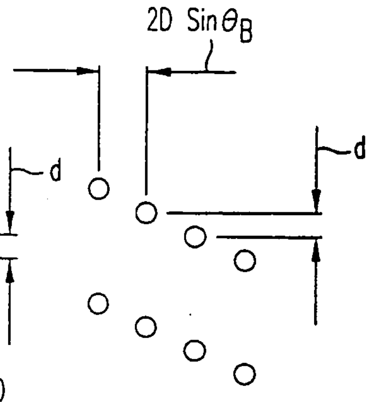


FIG. 4





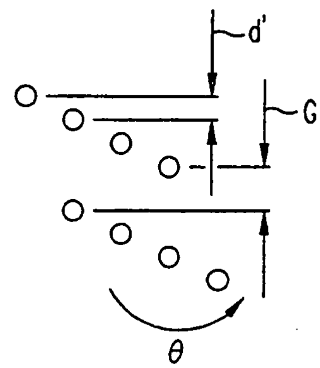


FIG. 5A

FIG. 5B

FIG. 5C

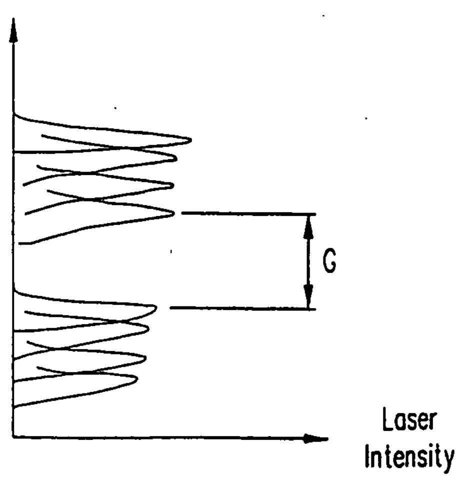


FIG. 5D

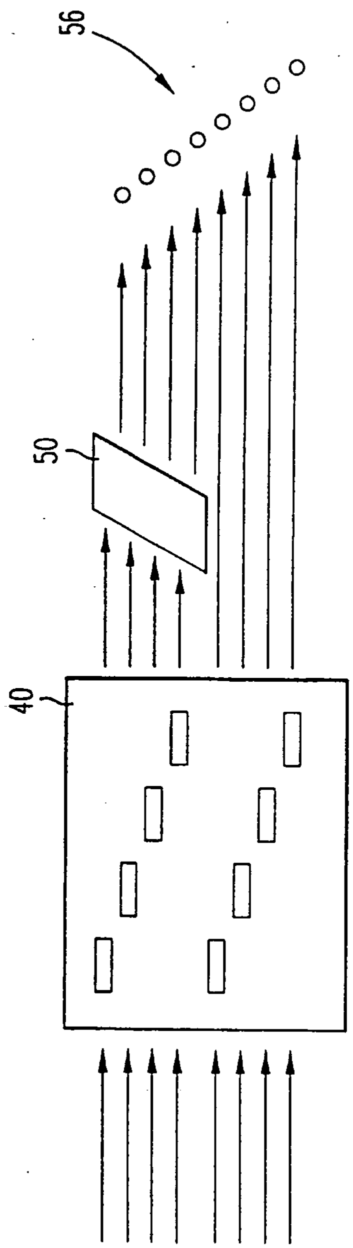


FIG. 6

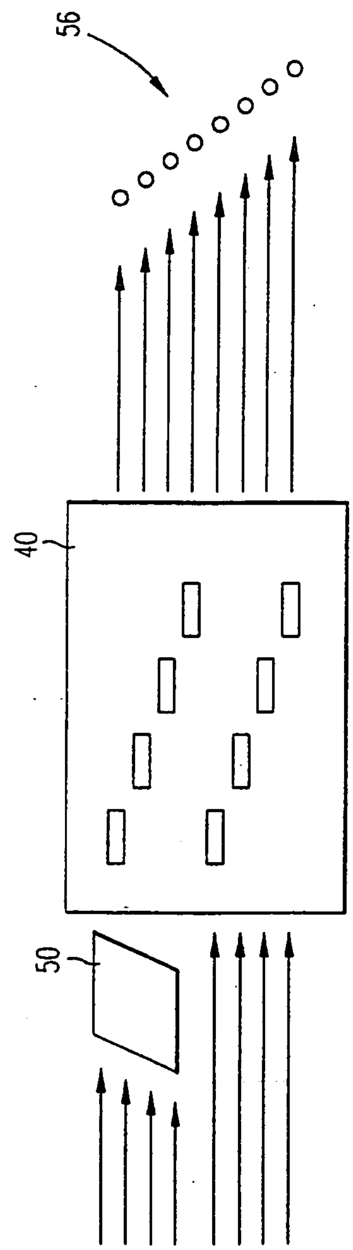


FIG. 7

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 98/12463

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02F1/11

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 342 290 A (THINK LABS KK) 23 November 1989	1-3
Y	see column 1, line 43 - column 2, line 18; figure 3	4
Y	EP 0 570 154 A (ORBOTECH LTD) 18 November 1993 see column 3, line 45 - column 4, line 45; figure 1A	4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 September 1998	05/10/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Lerbinger, K

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/US 98/12463

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0342290 A	23-11-1989	JP 1293315 A	27-11-1989
		US 5122897 A	16-06-1992
EP 0570154 A	18-11-1993	US 5309178 A	03-05-1994
		DE 69313347 D	02-10-1997
		DE 69313347 T	02-01-1998
		JP 6317772 A	15-11-1994